Session I:

History and Vision for the Future

Session Chair:

Speros Doulos
USFWS
Little White Salmon NFH Complex

THE COLUMBIA RIVER DEVELOPMENT PROGRAM: ORIGIN, HATCHERIES, LABS, PERSONALITIES, SUCCESSES, FAULTS

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Presentation

The Columbia River Development Program was incorporated into the U.S. Corps of Engineers budget to mitigate for the loss of mainstream spawning areas from the construction of Columbia River and Snake River dams. Al Kemmerick was appointed administrator of this program by the U.S. Fish and Wildlife Service in 1948, and he vigorously supported the construction of salmon hatcheries along the Columbia in Washington, Oregon, and later in Idaho. These 25 hatcheries each had a capacity of not less than 25 million chinook salmon smolts per year, some as much as 50 million, and the diet demands to rear these fish on animal liver and fish viscera would exceed national supplies – hence a salmon nutrition laboratory was authorized in 1950 and was completed by 1953 to determine the nutrient requirements of salmon and to develop a satisfactory diet for hatchery use. Roger Burrows was also expanding his diet formulation tests at the Leavenworth hatchery at that time and was cooperating with Tom McKee and Wally Hublou at the Seafoods Lab at Astoria for use of cannery fish viscera into production diets. Lauren Donaldson and Earl Norris at the College of Fisheries in Seattle had completed some work on an enzyme partially hydrolyzed fish tissue diet to rear trout in the school hatchery. The outcome of this diet was the world-famous Donaldson Trout which spread around the world.

John Halver was hired in 1950 to design, build, equip and staff the Salmon Nutrition Laboratory at Cook, Washington, and was given the mission of determining enough nutritional requirements of salmon to formulate an adequate salmon production diet within five to eight years (the time when most of the expanded hatchery program would be active in the Columbia River system). Scientists were hired with specialties in vitamin, protein, lipid, mineral, and carbohydrate biochemistry and were augmented with enzymologists, histopathologists, tracer chemists, and experimental laboratory technologists.

The lab went into full-scale operation in 1953. Monthly staff meetings were used to discuss recent findings and project new efforts in research. Regional and hatchery managers were invited to attend these meetings and suggest demanding current research needs. The hatchery systems then consisted of multiple raceways of fish fed extruded soft diets made of Burrows diet (1/3 liver, 1/3 spleen, 1/3 salmon viscera, bound with 2% salt). Large freezers were present at each hatchery to hold frozen supplies coupled with grinders, mixers and extruders for the diets. About this time, a sockeye salmon virus was found to be carried in the salmon viscera and it wiped out the sockeye salmon program at Leavenworth. McKee came up with a pasteurization process which was adopted the next year, and the salmon virus problem was eliminated. Still these diets were expensive and difficult to produce at different hatcheries; oxidized material occurred in the freezers, and the fish material often varied in composition. Millions of salmon smolts were reared successfully on these diets for many years, however. During the period 1957-1959, protein, amino acid, vitamin and fat tentative requirements for chinook salmon were published and the commercial fish feed industry rapidly expanded. Lyle Branchflower, Seattle, made a fish diet and heat treated it to kill disease organisms; Thorleif Rangen, Idaho, produced a pellet diet made from fish meals and agricultural by-products plus a vitamin and trace mineral supplement; Don Nelson also made pelleted diets in Utah; and Jesse Clarke made dry diets in New Mexico, and later joined Moore to produce the Moore-Clark frozen diets at LaConner, Washington. The large freezers at the many hatcheries were soon filled with these frozen pellets made from hydrolyzed fish waste or from fish flesh and combined with grain flours, fats and supplements. Many state and federal hatcheries adopted the frozen pellet diets.

The U.S. Fish and Wildlife Service and some state agencies contracted for salmon production diets with specifications for ingredients and for levels to be present in the formulations. Inspectors were hired to oversee production at the contractor sites. Diets were tested at new hatchery laboratories; Burrows moved to Entiat and later to Abernathy to build the Diet Development Laboratory. Expansion of the nutrition effort was also made by building the Hagerman Field Station with its 200 troughs of constant temperature water, and the Marrowstone Field Station with its saline and freshwater mixing capabilities. Both of these today are large stations with many capabilities to test diets, toxicity, smolting, seawater conversion, etc. Bob Smith put Hagerman together, and Clarence Johnson built Marrowstone at the old lighthouse station at the northeast tip of the island.

Historical personnel were the stalwarts in this Columbia River Development Program. Benny Cox developed and ran the Little White Salmon Hatchery with an iron hand. He took no umbridge, but would listen to well-thought-out and tested opinions. As a monthly visitor at Willard – at that time the Western Fish Nutrition Laboratory – he offered many practical pressing questions to be answered. Clyde Adams, our Native American Indian, ran the Spring Creek hatchery most successfully. Clyde said little, but listened well and out-produced most of the other hatcheries. Bernier ran Willard hatchery and was often in our hair at the laboratory urging us to work more on his pressing problems (which we often did). Bruce Kennedy ran the Wind River hatchery and, after he went to the Regional Office in Portland, Don Cairns built up the new Carson hatchery. Both were crafty opponents in either research discussions or especially in the poker sessions upstairs in the lab in the evenings. Roger Burrows was introducing his innovations in fish culture technology, first at Entiat and then later at Abernathy. His lot weighing techniques were adopted nationwide as the best for experimental lot weight measuring. Harlan “Red” Johnson was the experimental biologist at Dorena Dam in Oregon, and then moved to Little White to set up the first hatchery biology control lab for both disease and diet tests.

The first Northwest Fish Culture Conference was convened in Portland, Oregon, by Dr. Perry in 1950. Its purpose was to pool the thoughts of fish nutritionists, fish pathologists and fish culture technologists on what should be done to improve salmon production. Al Kemmerick of the Columbia River Development Program attended since he was the source of most of the funds for the proposals to be developed.   Roger Burrows was there, along with Rus Sinnhuber, representing Oregon State University; Tom McKee, the Seafoods Lab at Astoria; Bob Rucker of US Fish and Wildlife Service, for disease problems; and John Halver was invited to present the nutrition problems and to plan new research programs.

The next year, Roger Burrows was elected chairman and he organized a larger meeting inviting many of the fish hatchery managers to Wenatachee. Thus the Northwest Fish Culture Conference was formed and implemented.

More pioneers could be named, but this short list illustrates the type of dedicated personnel who laid the foundations for the current plethora of hatcheries, diet development, nutrition, disease and physiology labs in the Columbia River system today. As new information was disclosed, it was adopted by the state hatchery systems as well. Washington, Oregon, and Idaho have joined with the U.S. Fish and Wildlife Service efforts to improve fish culture in this area of the world. Each has something to contribute – to each unit a mission exists to integrate the knowledge and effort to understand the many parameters which in total make up successful fish husbandry.

CREAM CANS TO STAINLESS STEEL TANKERS

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Abstract

Cream cans to stainless steel tankers is a presentation on the history of Idaho Fish and Game's hatchery system. The presentation will show historic and current photos of hatcheries, old timers doing it the hard way and new technology of today's culturist. Then the results of all our hard work " Happy fisherman."

Presentation

Cream cans to stainless steel tankers is a presentation on the history of Idaho Fish and Game's hatchery system. In the "good old days" hard work and sweat were used to load fish into cream cans on Model T trucks and mule trains for transportation to Idaho waters. Today it is still hard work by dedicated fish culturists that raise fish for sportsman fishing in Idaho, but perhaps less sweat is shed with the development of new technology such as fish pumps and helicopters.

In 1907 Idaho state legislature authorized the construction of Hayspur Hatchery, Idaho's first fish hatchery. Since then 21 hatcheries and six satellite facilities have been constructed by State of Idaho, Idaho Power Company and Army Corps of Engineers. These facilities are operated by 62 permanent staff and a small army of temporary personnel.

The formation of Idaho Department of Fish and Game in 1938 shifted the administration of state hatcheries from the state legislature to the responsibility of the newly formed Fish and Game department.

Fish stocking records from 1913 to present show 25 species and approximately one-half billion fish have been stocked by Idaho hatcheries. Although our current mission statement may differ from the one of 1907, the final objective is the same; create fishing opportunity and happy fisherman. In 1996 4.11 million days of fishing effort was exerted by 486,000 fishermen.

FISH FOR THE FUTURE

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Presentation

In the opinion of many, the runs of hatchery-raised salmon and steelhead in the Columbia River Basin are declining at an alarming rate. So much so that some experts have opined that the demise the these runs will occur within the next 15-20 years. Reasons for this range from an ability to cope with the environment to being just plain inferior to their wild brethren.

In my opinion, the problem is much larger than the experts apparently think. The loss of natural spawning habitat through urbanization, timber harvest, mining, cattle and sheep grazing, and agriculture is a significant factor. The climatic changes in the ocean environment has altered the food supplies for many marine animals. The reservoirs created behind hydroelectric structures have provided havens for predators. The dams themselves have altered the downstream and upstream migration patterns. The hatchery environments have created significant behavior modifications that have reduced the survival potential of the smolts. And, lastly but not leastly, the politics of public and private agencies having some jurisdictional oversight of these fish and the basin, in general, have, in many cases, hindered the reduction of the overall problem.

Given the foregoing, one could think that the population reductions of Pacific salmon and steelhead is a problem unique to the Columbia River Basin. This is far from the case. Virtually all the natural and hatchery-raised runs throughout the Pacific Northwest are affected - some worse than others.

So, what to do? We cannot change the ocean environment - at least economically. We can reclaim some of the lost natural spawning habitat by limiting or restricting the activities contributing to their being lost in the first place. In this case, politics will be the influencing factor. We can remove the offending impoundments, thereby hopefully reducing the predation potential. We can collect the downstream migrants at appropriate collection sites and transport them around the reservoirs and dams.

In my opinion, there is not a single solution to this problem. The groups concerned with making plans and recommendations are being very short-sighted if they think this is so. For example, the breaching of the four dams will not solve one of the major problems associated with downstream migration. For example, the annual reports to BPA by Buettner and Nelson (1989; 1991) provide thought provoking conclusions on the smolt counts entering the Lower Granite Reservoir. According to their data, there have been, over the years, significant unaccountabilities of smolts from the Sawtooth, McCall, and Rapid River hatcheries in Idaho arriving at the Lower Granite Reservoir.

No one, to my knowledge, has addressed reason(s) for this degree of unaccountability. Along the way from the points of release to the Lower Granite Reservoir, there are no dams, no nitrogen supersaturation, no predators to speak of - just free-flowing rivers in their spring run-off condition. Thus, attention should point to something being associated with the pre-smolt period in their respective hatcheries. One could think that perhaps these hatchery fish could not swim competitively in the riverine environment. This seems quite reasonable since these fish have spent upwards of the past 14 months in an environment without too much velocity or turbulence and they were fed several times a day. At the time of smoltification they were released into rivers flowing at spring run-off velocities, turbulences, and clarities. Thus, it is quite reasonable to assume that many of these fish just could not cope with these conditions and became the "unaccounted".

If the foregoing logic is valid, then it further seems reasonable to assume that increasing the water velocities all along the course of the Snake and Columbia Rivers could worsen rather than increase the survival potential.

Perhaps a proposal should be developed and implemented at the Upper Snake River Basin hatcheries to increase the survivability of smolts raised at the Upper Snake River Basin hatcheries. The objective of such a study would be literally to teach the fish to swim during their residence in the hatchery environment. This could occur by making some very inexpensive and non-life-threatening modifications in the hatchery ponds.

Many researchers have considered swimming stamina of hatchery-raised and wild fish a very important criterion for performance in the natural environments (Horak, 1972; Greenland and Thomas, 1972; Green, 1964; Flagg et al, 1983; Besner and Smith, 1983; Black, 1965; Poston, 1975; Houlihan and Laurent, 1987). Evaluation of swimming stamina, in most studies, was accomplished by forcing the fish to swim against high water velocities to the point of exhaustion. The end-point was the maximum velocity that induced exhaustion during swimming periods of 2 to 80 minutes. Although most researchers deduced from their studies that better post-release survival might be correlated with swimming stamina, few studies were conducted to confirm this conclusively. Horak (1972) examined swimming stamina versus post-release survival but was unable under the test conditions used to demonstrate the relationship between stamina and post-release survival. Creswell and Williams (1983) examined the effects of pre-test exercise on swimming endurance. They concluded that hatchery fish should be conditioned to stream velocities at least two days prior to release if survival were to be increased. However, better post-release survivals were recorded following 14 days of pre-release exercise. This effect confirmed the observations of Burrows (1964), who reported increased adult return rates in populations raised for 7 months in circular tanks with high water velocities. Burrows also reported that the fish raised in circular tanks exhibited improved growth rates and increased swimming stamina.

I question the validity of assuming that swimming stamina per se is a realistic criterion for post-release riverine survival, an environment with which free-living populations of fish cope continuously. The majority of testing conditions used to evaluate swimming stamina primarily measured the ability of the fish to tolerate elevated levels of white muscle lactic acid with its attendant decrease in blood pH (Johnston, 1982). The light muscle, used primarily for short-lived burst swimming, functions anaerobically and is quite susceptible to fatigue. The dark muscle, used primarily for sustained swimming activity, functions aerobically and is very resistant to fatigue.

The observations of Burrows support the contention that long-term physical conditioning has merit. There are conclusive data to demonstrate that fish can be conditioned for increased growth performance and sustained swimming capacity. For example, fish required to swim in sustained water velocities of 1.0 - 1.5 body lengths per second exhibited higher growth rates than did their counterparts in still waters (Leon, 1986; Jobling, 1991; East and Magnan, 1987; Davison and Goldspink, 1977; Houlihan and Laurent, 1987; Greer-Walker and Emerson, 1978; Christiansen et al., 1989). There was agreement by all authors that prolonged exercising improved feed conversions and increased the amount of feed required for satiation (Jobling, 1991). More significantly, there were exercise-associated changes in body composition; i.e., significant increases in muscle mass (Davison and Goldspink, 1977), increases in body protein and decreases in lipid (Jobling, 1990; Christianson et al., 1989).

In addition to quantitative changes in proportions of muscle tissue, there were exercise-associated histological changes in the light and dark muscles (Johnston, 1982; Davison and Goldspink, 1977). Others reported associated changes were a decrease in oxygen demand in stressor conditions (Woodward and Smith, 1985) and an increased stamina to high water velocities and turbulences (Burrows, 1964).

The foregoing citations conclude that several weeks of exercise are required to create a significant proportional increase in dark muscle. Perhaps it would be better to condition the fish throughout the majority of their pre-smolt period under controlled hatchery conditions.

To reduce the behavior modification potential the investigative conditions should include irregular feedings and sprinklers providing a visual barrier between the fish and the feeder. Fish in the wild feed irregularly with periods of high expenditure of swimming energy to cope with the water velocity and to avoid predators. Studies conducted under laboratory conditions have demonstrated the efficiency of irregular over regular feedings (Klontz et al., 1991). Fish fed irregularly displayed less interfish aggression (as evidenced by fin nipping). Also,there were less size variations within populations and no negative effects on feed conversions. Intermittent feeding also generated positive effects on growth performance and body condition.

There is little information on the effects of exercise combined with irregular feedings or short periods of starvation. Black (1965), in studies of the effects of short-term exercise and starvation on glycogen metabolism, observed significant decreases in blood glucose levels following two minutes of strenuous swimming by starved fish.

There are no known studies addressing the combined effects of long-term exercise and feeding regimen. Also, there are no known reports of post-release survival following long-term exercise and irregular feeding regimens.

An approach to evaluate the effects of long-term exercise on post-release survival and adult returns should consist of pre- and post-release evaluations. Also, identifiable groups of fish on the exercise and not exercised regimens should be established at each of the involved hatcheries.

In the pre-release portion, ponds - whether they be raceways or circulating ponds - could be configured to provide specified water velocities by altering either the cross-sectional area of the pond (raceways and Burrows ponds) or the angle of water inflow (circular ponds). Raceways could also be configured to provide specified water velocities by inserting two sets of longitudinal panels in the ponds to provide an S-shaped flow. In addition, ponds could be provided with sprinklers to reduce the visibility of the staff at feeding times. Ponds used for the non-exercised (Control) fish could be used unmodified. Prior to release from the hatchery environments, sufficient numbers of fish in both groups - Test and Control - could be tagged for downstream monitoring after release and return as adults some years later.

The pond loadings should be no more than 50% of the maximum allowable population densities. One of the major stress inducers in the hatchery environment is population density. For some reason, in years gone by, it was considered efficient to have densities of 50-75 kg/cubic meter. The result was and is a "swimming fankfurter" because of the fin loss through nipping or a "midnight special" because of the generalized melanosis.

During the pre-smolt period, data to evaluate the following performance parameters should be collected on a regular basis; i.e., biweekly or monthly. I am suggesting the consideration of 15 performance indicators, which are:

1) <u>Growth</u>, which can be measured as a function of changes in length, weight and condition factor. The daily length and weight increases may be affected by the combination of exercise and feeding regimens. The condition factor is considered to be directly related to fitness and should be within a definite range for post-release survival. The exercise and feeding

regimens should affect this parameter. It should be considered as an important response variable for future hatchery practices.

2) Size variation, which is primarily the result of food availability and the individual feeding aggressiveness of the fish. It can be measured as the coefficient of variation for population lengths and weights.

3) Feed conversion ratio, which is not one of the prime considerations of these studies although reports in the literature imply that there will be improved feed conversion ratios with exercise.

4) Specific growth rate, which can be calculated the method developed by Focht (1983). The formula accounts for decreasing age-dependent growth rates and has been shown to be quite useful under hatchery conditions. The formula is:

$$SGR = ((1 + (W_e - W_i) / W_i)^{(1/n)} - 1) * 100$$

Where: SGR = Specific growth rate (%/day)
W_e = Weight (g/fish) at the end of the growth period.
W_i = Weight (g/fish) at the beginning of the growth period
n = Number of days in the growth period
100 = Decimal-removing factor

5) Organosomatic indices, which can be determined using the Goede method described and implemented by Warren (1990). These morphometric, physiological and chemical values can serve to document the physical condition of the fish. These data should contribute to the interagency data bank.

6) Muscle mass and histology, which can be determined on a bi-monthly basis. These evaluations should also be done on recovered post-release hatchery fish and wild fish.

Fish experiencing long-term exercise have been shown to have an increase in muscle mass and alterations in proportions of dark (sustained swimming) and light (burst swimming) muscle (Davison and Goldspink, 1977). There was also an attendant increase in dark muscle fiber diameter with sustained exercise (Johnston, 1982; Davison and Goldspink, 1977).

7) <u>Hematological parameters</u> consisting of hematocrit (% packed cells), hemoglobin (g / 100 ml blood), erythrocyte count (n / mm^3), mean corpuscular volume (nm^3), mean corpuscular hemoglobin (uug), mean corpuscular hemoglobin concentration (%), and serum proteins (g / 100 ml) can be determined using standard methods. These parameters are considered to be invaluable physiological criteria when employed properly for assessing the physiological status of fish.

8) <u>Proximate analysis</u> of whole fish, muscle, and viscera can be determined. This is to evaluate relative changes in lipid and protein levels during the course of the study. It is assumed that lipid contents will be negatively correlated to sustained swimming ability and post-release survival. Protein content is directly correlated with muscle mass, thus exercise should generate increases in protein levels apart from those occurring as growth.

9) <u>Oxygen demand</u> (Standard Metabolic Rate) (SMR), which can be determined using the method described by Klontz et al (1983a). The SMR is an indicator of the ability of fish to respond to stressful situations. Woodward and Smith (1985) noted that exercised fish exhibited a decreased SMR during short-term periods of stress than did their unexercised counterparts.

10) <u>Prevalence of environmental gill disease</u>, which is a frequent clinical manifestation of a chronic stressful situation, also affects the SMR by requiring an increased pO_2 to satisfy the blood oxygen demand (Klontz et al 1985). Thus, the SMR data could be influenced by this condition. Examination can be made by wet mounts of the gill tissues. Quantification can be based on severity using a scale of 1 - 5 (1 = no change; 5 = occlusive interlamellar hyperplasia).

11) <u>Prevalence of latent bacterial infections</u> , particularly *Renibacterium salmoninarum*, which can affect the physiological responses to stressful situations. Examinations for *R. salmoninarum* and other organisms endemic to the study hatcheries can be conducted by the ELISA method.

12) <u>Mortality</u>, which is a response to the inability of the fish to cope with its environment or to the occurrence of a microbial pathogen. Thus, the exercised fish should have a lower cumulative mortality than their unexercised counterparts.

13) <u>Social behavior patterns</u>, which can be measured by the prevalence of fin nipping at times of inventory. Post-release behavior in the wild should be

recorded for comparative purposes. This will require the cooperation of agency field personnel.

14) <u>Feeding behavior</u> of post-release fish, which can be evaluated by examining the stomach contents of recovered post-release hatchery fish and wild fish. The questions to be answered are:

a. Did the hatchery fish ingest the same foodstuffs as the wild fish?

b. How rapidly following release did the fish begin to eat?

c. Is there a relationship between in-hatchery feeding regimen and post-release feeding behavior and food preferences?

15) <u>Recovery</u> of tagged fish released from the study hatcheries, which is the one of the main purposes of these studies. The collected fish should be sampled for the same physical and physiological examinations conducted on the fish in hatchery studies.

In conclusion, the foregoing is but one approach to reducing the downstream migrating smolt loss and increasing the adult returns. To some, it may seem a bit facetious to say that one of the best ways to reduce fish mortality is to teach the little beggars to swim. Also, to some, the list of performance indicators may seem a little excessive and more appropriate to the university laboratory, although, if one thinks about it, they are not excessive and they belong in a hatchery study. Finally, if one thinks the approach has merit and implements it or another like it, I will have been successful in my efforts. And, I am willing to help in any way I can.

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HATCHERIES OF THE FUTURE

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Presentation

From all the reports and opinions generated by the experts on the status and future of the salmon and steelhead runs, one could assume that the current hatcheries raising Pacific Salmon and steelhead in the Pacific Northwest are more a detriment than a benefit to preserving the runs. The main concern expressed is the behavior modification factor. These fish during the first 14-16 months of their life are raised in virtually static water systems, in often highly crowded conditions, fed regularly a manufactured diet, and subjected to all manner of physical handling stressors. At the end of their hatchery residence period - in the spring months when the snow melt has raised stream levels and velocities significantly - the smolts leave the hatchery environments and migrate seaward. A significant portion of them do not make it into the marine environment.

Along the migration route there are several environmental factors which affect smolt survival. First, leaving the peace and tranquility of the hatchery environment and entering a raging torrent provides the first impediment. In Idaho, according to IDFG biologists, significant numbers of smolts from the Rapid River, McCall, and Sawtooth hatcheries are lost before they enter the Lower Granite Reservoir - and there are no dams along the way - just highly turbulent, murky water. It has been speculated that these smolts lack the ability to swim. Those which survive the first leg of the journey arrive at the first reservoir probably quite elated at reaching a stretch of quiet water only to find that their feeder - the hatcheryman - is not there to provide them with some food. While in the reservoir trying to figure out which way to go comes the next peril - the predaceous squawfish and walleye pike. Since this is all new, the predators are not regard as perilous. So many get eaten. By now the original number has been reduced by as much as 50% and there may be several more reservoirs to traverse. Finally some make it to the estuary and the fish-eating bird populations. What few are left to pass into the marine environment than face the task of finding food and staying clear of predators -even their own species but a year or so older. But, alas, El Nino and his sister, La Nina, have created water conditions unable to provide sufficient food for the survivors. As a result, after 2-4 years of ocean life, many adults return to their streams of origin in often quite an emaciated shape, which is not conducive to upstream migration and survival to the spawning grounds.

So, what to do? How can we return this dismal scenario to some semblance of normalcy?

First, husbandry practices must be changed to meet the needs of the fish and not those of the administrators in the front office many miles away. Decisions such as how many eggs and/or fish can a facility produce must be made by the resident staff. Pond loadings must be made on the basis of being virtually stressor-free. The practice of trying to raise 10 lbs of fish per cubic foot of water is not doing the fish any favors. And the practice of trying to raise 10 lbs of fish per gpm is also not doing the fish any favors.

The suggested population densities should not exceed 50% of the calculated maxima based upon Piper's Density Index. The pond loading should also be such that the outfall dissolved oxygen is never less that 70% of saturation. This probably means that a given facility probably will produce less numbers of fish than previously. If history is any indicator, fewer numbers of better fish are more likely to return to harvest and spawn than are larger numbers of physiologically compromised fish.

Inventories of ponds should be done so as to minimize the stressor factor. Fish should be off feed for at least 24 hours. Grab samples - at least 5 samples of 20 fish - should be anesthetized and the individually weighed (+/- 0.01 g) and measured (+/- 1.0 mm). Calculations should include the mean, median, range and mid-range of values, the standard deviation, the coefficient of variation, condition factor and the specific growth rate.

Feeding should be done on an irregular basis - skipping a day now and again. In fact, not feeding on week-ends has been quite good. This method reduces the habit-forming potential.

Second, pond design must change so as to provide the fish with a moderate degree of exercise. According to the Norwegian workers, the ideal water for salmonids should be between 1.0 and 1.5 body lengths per second. To achieve this, raceways can be modified inexpensively with plywood groins to create a zig-zag water flow. The water inflow to rectangular circulating ponds; e.g., the Burrows pond, the Rathbun pond, the Richardson D-end pond, and circular ponds can be modified to provide the proper water velocities.

Third, ponds should be fitted with a sprinkler system so that the fish believe they are living in a perpetual rainstorm. The food comes from somewhere above.

Fourth, transferring fish from pond to pond or to transporters should be done with the fish in water not in nets.

Fifth, record-keeping must be improved and standardized so that tracking populations through several year classes is possible. Daily mortalities, treatments, water temperatures and dissolved oxygens, feed conversion ratios, specific growth rates, and special activities must be included.

Now for the grand finale: What should a hatchery of the future be? First, it should be built on a hill-side with gravity flow water. Flat land hatcheries do not provide sufficient gravity to move water quickly. Second, ponds should be of the single-pass rectangular circulating types with supplemental aeration; e.g. the Richardson D-end pond. This configuration provides common walls and is no more space consuming than a raceway system. Raceways, especially multiple-pass raceways, should be considered historical. In my opinion such systems throughout the years have been a major causal factor in episodes of noninfectious and infectious disease. Plumbing should be such that fish can be moved between ponds by swimming through a pipe using a movable screen stimulus. It also should be such that smolts and adults can be moved to and from transporters by swimming through a pipe. Third, feeding should be done with mechanical feeders set for irregular intervals. Fourth, pond populations should be monitored by yet-to-be-designed electronic instrumentation. All mathematical calculations should be done using computerized programs designed by a systems analysis engineer - the "new kid on the block". And finally, resident staff must live on site. Off-site staff relying on alarm systems is not not practical.

And, that about does it. But, until this type of facility is a reality, we must use what we have to its best advantage.

Now a message for the "old timers" - Use these youngsters coming out of university programs. Their primary function is to make you look like a million dollars. Please do not try to make them over into your image. Let them "bloom and flower". They should have received state-of-the-art methods of intensive fish culture during their university years you might be surprised what can be learned from them. These folks are the future to solving this whole mess we have allowed to be created.